CONTINUOUS FIBER CERAMIC COMPOSITES

Project Fact Sheet

CFCC IMMERSION TUBE

BENEFITS

CFCCs offer all the advantages of ceramics - resistance to heat, erosion, and chemical activity - while adding toughness and thermal shock resistance. CFCCs enable a substantial increase in energy efficiency and decrease life cycle costs in a broad range of industrial applications. Specific benefits of the CFCC immersion tube include:

- longer tube life and greater energy efficiency than the current heater tube technology.
- significant energy savings due to reduced heat-up time and operating temperature

APPLICATIONS

CFCC burner tubes can be used as immersion heaters and burners for light metals casting, including aluminum, zinc and magnesium. Since the immersion tubes being replaced are of a similar design, the barriers to entry are minimal. The potential users are receptive to evaluating the composite immersion tube. The aluminum metal casting industry is potentially the largest market. The automotive industry in particular is moving to lighter metals to deal with increasingly demanding gasoline mileage and emission standards.

NITRIDE BONDING PROCESS USED TO FABRICATE CFCC IMMERSION TUBES

The U.S. Department of Energy's Office of Industrial Technologies (OIT) initiated the Continuous Fiber Ceramic Composite (CFCC) Program in 1992 as a collaborative effort between industry, National Laboratories, universities and government.

Through support of the CFCC Program, Textron Systems is developing a ceramic composite consisting of silicon carbide reinforcing fibers in a nitride-bonded silicon carbide matrix. The reinforcing fibers are silicon carbide monofilaments or SCS-6, which are also produced by Textron Systems. CFCC tubular structures are being fabricated using a filament winding process. The CFCC tubes may be coated or infiltrated, if necessary, to reduce porosity and enhance durability.

Textron Systems has teamed with Deltamation (a furnace designer) and a major automotive casting facility to develop and test CFCC immersion tubes to melt aluminum. Currently, aluminum is melted in reverberatory furnaces or in furnaces with radiant burners. These methods of aluminum melting have several limitations: (1) efficiency is limited, resulting in at least 60% heat loss; (2) the formation of scale contaminates and lessens the quality of the aluminum; and (3) heating of the aluminum is nonuniform. CFCC materials have the potential to increase efficiency, demonstrate uniform heating characteristics, substantially reduce contamination and increase throughput. Unlike monolithic ceramic tubes, the CFCC tubes also resist thermal shock. In addition, CFCCs are not wetted by molten aluminum and are not chemically attacked.

IMMERSION TUBES

CFCC immersion tubes (36 inches long - shown above entering a melt pot) may be an energy efficient alternative for melting aluminum.

Project Description

Goal: The goals of this project are to: 1) optimize the nitride bonded silicon carbide fiber reinforced CFCC immersion tube burners for application in aluminum and other light metal melting; and 2) demonstrate processing methods for the fabrication of low-cost ceramic composite tubes.

This project is validating, by long term testing of representative components and by post-test evaluations, that CFCC materials are stable for long periods in both molten aluminum and in combustion gas. A cost model will be developed to verify that the fabrication cost of CFCC tubes is compatible with customer requirements.

As exhibited by this project, the CFCC Program is addressing the critical need for advanced materials that are lighter, stronger, and more corrosion-resistant than metals. The Program strives to advance processing methods for reliable and cost-effective ceramic composite materials to a point at which industry assumes the full risk of development and commercialization. The long-term strategy is to develop the primary processing methods for reliable and cost-effective fabrication of CFCCs and to perform application-specific testing which will meet the needs of a wide range of energy saving applications in industry. These industries include: power generation, agriculture, aluminum, steel, chemicals, forest products, glass, metal casting, mining and refining.

Progress and Milestones

- Conducted stress analysis to estimate the stresses imposed by the aluminum melting application and to design the fiber architecture to provide reasonable design margin.
- Successfully developed and fabricated full-size immersion tubes. The full-size tubes were provided to F.W. Shaefer (a furnace manufacturer) and Doehler-Jarvis (an aluminum caster) for integration into a furnace and testing in a realistic environment of combustion gases on the inside and molten aluminum on the outside.
- Achieved substantial improvements in the CFCC material and filament winding process. Specific improvements have included a new 5-axis filament winding machine, a nitriding furnace with better controls to assure complete nitridation of the silicon precursor, and invention of a seamless mandrel.
- An immersion tube survived over 1,000 hours and 31 casting cycles in an aluminum casting furnace at an industrial site.
- Another immersion tube successfully survived 1,752 hours of testing. This tube experienced one cold start up, two modified start ups (less severe than cold starts), and 47 casting cycles.
- Multi-tube testing in an aluminum casting furnace is planned at a major automotive casting facility for 1999.

Project Partners

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Composite Optics, Incorporated
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